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ntec, d/n ltr, 21 jun 1977

TECHNICAL NOTE: NAVTRAEQUIPCEN TN-53

EVALUATION OF THE DUKANE CASSETTE/FILMSTRIP PROJECTION SYSTEM MODEL 28A28A

Support, Test and Evaluation Division
Naval Training Equipment Center
Orlando, Florida 32813

March 1976
Final Report

NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

Technical Report: NAVTRAEQUIPCEN TN-53

EVALUATION OF THE DUKANE CASSETTE/FILMSTRIP PROJECTION SYSTEMS MODEL 28A28A

F. P. Samulenas
Support, Test and Evaluation Division

March 1976

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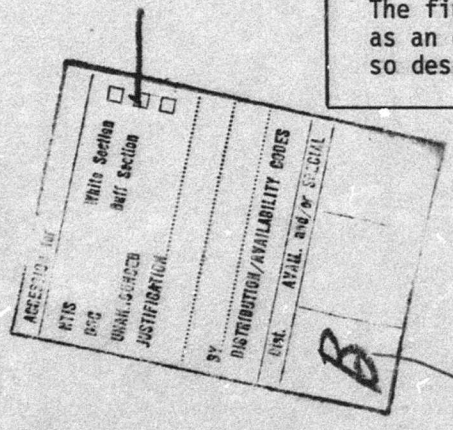

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NAVTRAEQUIPCEN TN-53	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Evaluation of the Dukane Cassette/Filmstrip Projection System Model 28A28A	5. TYPE OF REPORT & PERIOD COVERED: Final Report
6. PERFORMING ORG. REPORT NUMBER: NAVTRAEQUIPCEN TN-53	
7. AUTHOR(s): F. P. Samulenas	8. CONTRACT OR GRANT NUMBER(s): 26 p.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Support, Test and Evaluation Division (Code N-234) Naval Training Equipment Center Orlando, FL 32813	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: USATDA Work Assignment No. 7053
11. CONTROLLING OFFICE NAME AND ADDRESS: Commanding Officer Naval Training Equipment Center Orlando, FL 32813	12. REPORT DATE: March 1976
	13. NUMBER OF PAGES: 28
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Chief of Naval Education and Training Support Pensacola, FL 32508	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U. S. Government agencies only; Test and Evaluation, March 1976. Other requests for this document must be referred to the Commanding Officer, Naval Training Equipment Center (Code N-423), Orlando, Florida 32813.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Filmstrip projectors, photographic projectors, still projectors, sound/filmstrip projectors, 35mm filmstrip projectors

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results obtained from evaluating the performance of two units of the Dukane Cassette Filmstrip Projector, Model 28A28A. The main purpose of the evaluation was to develop reliability and maintainability information and to identify early failure mode developments in the machines. The evaluation was sponsored by the US Army Training Device Agency (USATDA) in Orlando, Florida.

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BLOCK 20. ABSTRACT (continued)

The evaluation consisted of electronic, optical, mechanical and audio performance tests conducted both before and after accelerated usage tests involving 27,000 cycles of operation or the equivalent of up to three average years of use for most of the machine functions. The reliability and maintainability information obtained from the test lead to the following general statement: If the machine is properly cleaned (suggested) on a regular basis and maintained through the yearly preventative maintenance program, the projector should provide trouble free performance for nearly an unlimited period of service classroom use.

Based on the test results, recommended levels of spare parts for inventory have been listed. Recommendations concerning modification or redesign of the K1 relay function and incorporation of a wiring harness disconnect has been made and a recommended maintenance schedule included.

SUMMARY

The purpose of the test and evaluation of the Dukane Cassette/Filmstrip Projector Model 28A28A was to develop Reliability and Maintainability information, termed RAM data, for the Army on representative samples of that device.

The challenge involved in this assignment was to develop a test that would isolate primary failure modes of the device thereby allowing the cognizant Reliability and Maintenance team representative to accurately predict the spare parts and maintenance support needed for their deployment throughout the world. Both real-time life testing techniques and accelerated usage tests and analysis were conducted and the results applied to the development of RAM data. Enough information was accumulated to generate a high level of confidence in the operation of this projector in suitable Army training.

The analysis was conducted by a team of engineering test and evaluation personnel including R. L. Hirvi, N-411, E. R. Follensbee, N-231, P. E. Dietzel, F. P. Samulenas, M. R. Thorpe, M. G. Rollerson, R. Singer and R. C. Thomas of code N-234.

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SECTION I

INTRODUCTION

The US Army Training Device Agency (ATDA) requested the test and evaluation of the Dukane Response Super Micromatic Filmstrip Sound Projector Model 28A28A for the purpose of determining the suitability of the projector for Army training. In addition to a performance evaluation, the Army requested that the evaluation develop Reliability and Maintainability information (RAM data).

Two Dukane Filmstrip Sound Projectors, serial numbers 537906, designated as Dukane #1 and 538433, designated Dukane #2, were purchased off-the-shelf by ATDA for use in this test. These projectors were then subjected to a series of preliminary but precise tests measuring their electrical, electronic, mechanical, optical and acoustical performance. Accelerated usage test and shock tests were then applied to one of the units after which the preliminary tests were repeated. Additional operational tests were applied to the second unit as well as to the unit to which the accelerated usage tests had been applied. Degradation of performance characteristics and the accumulated failure data was then used in the RAM analysis to provide the basic output for this report.

SECTION II

PROCEDURE

The primary requirements for the evaluation which determined the procedure to be followed were to develop RAM data and identify machine design weakness. The project team combined these requirements with the applicable performance standards and usage requirements of a typical Army training situation and designed a series of tests incorporating these factors. The performance requirements, usage factors and test formulations subsections follow:

PERFORMANCE REQUIREMENTS

The Dukane Response Super Micromatic Filmstrip Sound Projector Model 28A28A was primarily designed for use in average size classrooms, however, it can be used to project filmstrips for small groups. A small screen is included inside the carrying case for limited audience groups. The units contain automatic or pushbutton advance controls for 35mm filmstrips with tape cassette sound. The response feature is designed to "hold" the picture on the screen and halt the audio until the student presses a button to continue the program. A complete description of the unit's operation and features may be found in Appendix A.

The Dukane projector should meet or exceed the following spedifications:

a. Lamp Life: 50 hours

b. Screen Brightness: 250 lumens (medium sized classroom)

c. Audio Output Power: 2 watts at less than 5% harmonic distortion

d. Frequency Response: 60-3000 Hz, +0 dB -5dB with response to 333 Hz 0 reference

e. Audio Signal-to-Noise: 40 dB unweighted @ 333 Hz (NAB)

f. Flutter and Wow: 0.3% RMS unweighted (NAB)

g. Picture Resolution: 50 line/mm (AWAR)

h. Projector Mechanism Audible Noise: <50 dBA at distance of 4 feet from mechanism

USAGE FACTORS

Assumptions were made that the projectors would be used for six hours a day, five days a week and fifty weeks per year. It was also estimated that as many as six ten-minute programs might be shown per hour, which as shown in Appendix B, would result in 9,000 usage cycles per year.

Also presented in Appendix B is the assumed sequence of events in a usage cycle and the calculations used to develop average program length.

FORMULATION OF TEST AND ANALYSIS PROCEDURES

a. Preliminary Tests

A series of preliminary tests were formulated to measure system performance in order to determine if any problem areas existed which would affect training effectiveness in field use. These tests were run before and after accelerated usage testing to determine changes in performance as a result of

use. An outline of the tests and their significance can be found in Appendix B. A list of the preliminary tests conducted is as follows:

(1) Cassette Tape Deck Performance

(2) Power Consumption

(3) Lamp Life

(4) Audio Frequency Response

(5) Audio Power Output and Distortion

(6) Audio Signal-to-Noise Ratio

(7) Wow and Flutter

(8) Light Output

(9) Picture Resolution

(10) Mechanical Noise Level

b. Accelerated Usage and Shock Tests

Dukane projector #1 was subjected to a mechanically accelerated usage test and shock test at a commercial test laboratory (CTL). These tests are described in some detail in Appendix B. All tests were performed under daily monitoring by NAVTRAEQUIPCEN project personnel. The commercial test laboratory performing the following tests operated on a 24-hour a day, 5-day week basis. The tests performed by this laboratory were designed to simulate typical field usage of the projector. The typical field usge was not intended to be average but conditions were intended to vary from good to bad representing a real world situation.

Duake projector #2 was subjected to an accelerated life test accomplished in-house. The test utilized the synchronous pulses on the audio cassette to advance the film mechanism through a cycle of operation described in Appendix B. This test was also designed to simulate typical field usage limited to the electronic and film advance portions of the projector and was conducted until failures occurred. The early failures were repaired and necessary adjustments made until sufficient failure information and other data was developed to provide, in conjunction with data from mechanical and accelerated tests, the means for calculation of satisfactory reliability and maintainability estimates.

SECTION III

PERFORMANCE EVALUATION

PRELIMINARY TEST RESULTS

The test procedures and results from the tests described as preliminary in Section II, are discussed in some detail in Appendix B. As stated previously these performance tests were conducted before and after the usage and shock tests for the determination of sometimes hard-to-detect wear and indications of early failure modes. However, these tests also provide a check on the initial quality of the devices as compared to the manufacturer's claims and specifications, industry standards, or the minimum levels considered to be satisfactory by the evaluation team. A summary of these test results follows. Scrutiny of these values indicates that both units operated in a satisfactory manner and the initial quality of the projectors was good:

Tape Speed	1.875 ±3% inches per second
Rewind Times	Less than 2.5 minutes for C-60 cassette
Fast Forward	Less than 3 minutes for C-60 cassette
Wow/Flutter	Less than 0.2% RMS
Total Harmonic Distortion	Less than 3% at 1.6 watts output into 16 ohms
Take-up Torque	40 ±5gm-cm (adjustable at service interval)
Head Azimuth	Adjustable as required at service interval
Picture Resolution	Greater than 50 lines/mm (AWAR)[1]
Signal-to-Noise	-49 dB unweighted @ 333 Hz (NAB)
Light Output	Greater than 370 lumens
Power Consumption	Less than 570 watts
Lamp Life	55 ± 10 hours
Audio Power Output	1.6 watts into 16 ohms with 3% THD at 1KHz
Frequency Response	63 Hz to 2000 Hz -5 dB @ 63 and 2000 Hz with respect to 333 Hz 0 refcrence

[1]Area weighted average resolution as defined in Mil Std 150A.

ACCELERATED USAGE AND SHOCK TESTS

a. Operational Cycle Mechanically Accelerated Usage Test

This was one of the most important tests conducted in the evaluation and together with the test discussed in paragraph b. below was used to develop the RAM data required and discussed in Section IV. The test was performed as outlined in the previous section and the results are discussed in some detail in Appendix B. Lack of failures or significant degradation in this test demonstrated that the projector is mechanically sound and that probably no significant hardware or software interface problems exist.

b. Film Advance Electronically Accelerated Usage Test

This test was conducted until a number of failures occurred on the projector and the data generated is discussed in Section IV. The test was performed as outlined in the previous section and the results are discussed in some detail in Appendix B. It should be noted that the same filmstrip and audio cassette operated throughout the test and were still operable at the completion of the test. As discussed in Appendix B this is a preliminary indication that wear-out is encountered.

c. Shock Test

The shock test is also briefly discussed in Appendix B. This test did not produce either an operational failure or detectable degradation in projection system performance.

POST USAGE AND ENVIRONMENTAL TEST RESULTS

All of the preliminary tests described in Section II were repeated following conclusion of the two usage and shock tests. Other than the wear of belts, rollers, other elements of the film-advance mechanism, and the failures developed in the test-to-failure portion of the evaluation, no degradation of performance or incipient wear of the machine could be discerned.

SECTION IV

RELIABILITY AND MAINTAINABILITY ANALYSIS

RELIABILITY OF THE DUKANE SYSTEM

The electronic piece parts prediction for the machine is calculated to be 350 hours mean time before failure (MTBF) as detailed in Appendix C. Mechanical degradation is estimated to reduce the machine performance by approximately 30%, i.e., 105 hours, giving an overall predicted MTBF of 245 hours. During this accelerated test three failures occurred over 865 total hours resulting in an observed MTBF of 288 hours. This value correlates closely with the predicted MTBF for the machine.

MAINTAINABILITY OF THE DUKANE SYSTEM

From the viewpoint of maintainability, the device has both good and bad features. Failure of the K1 relay required drilling to remove attaching rivets. Those were changed to replaceable fasteners. The wire harness from the cover mounted control panel to the chassis should be provided with a quick disconnect to facilitate maintenance. The PC boards are easily removed, however, other components hardwired in place are often difficult to remove. The R4 fuseable resistor is difficult to remove and should be replaced with a panel mounted fuse-in-holder and necessary resistor. Belts and films advance mechanism are easily serviced. The bulb and lens assembly are also easily serviced. The service manual supplied by Dukane was considered useful, but does not include detailed assembly and adjustment procedures. Another failure was the B+ regulator transistor, 2N5295. Additional problems could have been experienced if the transistor shorted and the B+ supply for the transistor modules was not fused.

SECTION V

CONCLUSION AND RECOMMENDATIONS

The Dukane projector Model 28A28A proved to be one of the most reliable projectors tested by this activity. Cassette tape and film wear was minimal for the duration of the test. This lack of wear indicated that Army program material will not be likely to wear-out due to average use before update and resulting replacement of the material is necessary.

Enough usage was applied to the units during the test period to determine the necessary quantities of parts to be stocked. This information can be found in Appendix D. Maintenance operations and schedules were also developed and can be found with the parts list information in Appendix E. Periodic routine maintenance was considered to be necessary for successful use of this projector. The tape heads, pinch roller, and capstan should be cleaned with isopropyl alcohol on a cotton swab. The heads, pinch roller and capstan should be demagnetized weekly. In addition a remote cord assembly (Dukane part #200-56) might be found to be useful if furnished with each projector to start/stop programs manually.

APPENDIX A

GENERAL DESCRIPTION OF THE DUKANE MODEL 28A28A CASSETTE FILMSTRIP PROJECTOR SYSTEM

DESCRIPTION OF SOFTWARE UTILIZED AND PROJECTOR SOFTWARE INTERFACE

The program material used in the Dukane Model 28A28A is a standard 35mm single frame filmstrip and the standard Philips audio cassette. The maximum length of the filmstrip is limited to 200 frames including the head and tail leader. Sixteen frames in the filmstrip are equal to 12 inches, so a total of 200 frames is 12.5 feet long. A standard 35mm single frame is masked within the filmstrip .668 inches vertically and .885 inches horizontally.

The production of filmstrips is made in accordance to the ANSI PH-7.1-1971 standard. Good quality C-60 or shorter audio cassettes such as Norelco, B.S.A.F., Scotch or TDK are recommended for use with the projector's tape deck. The C-60 audio tape cassette will play up to 30 minutes per side in the Dukane projector's tape deck. The use of a single side for programming is recommended to eliminate possible errors in playback. Audio tape cassettes that play longer than the C-60 are not recommended for use in the Dukane projector.

Both the program audio and the 50 Hz inaudible sync pulses are superimposed on the same track utilizing only half of the cassette tape width. Programs are kept in synchronization by film advance pulses from the audio cassette, however, the unit is not capable of reverse synchronization. The audio cassette can be rewound for replay, but the filmstrip can only be rewound manually by turning the framing knob.

Once focused on the first frame, the rest of the program remains in constant focus throughout. The filmstrip is held flat between two pieces of glass mounted in the aperture area of the film carrier. Projected images can be left on the screen indefinitely without refocusing.

Filmstrips never require rewinding when used properly in the Dukane projector. After the completion of a program, the filmstrip is replaced in its container or rethreaded in the projector for review. Placed in the cup provided on the top of the projector, the filmstrip is fed out of the center and manually threaded into the top of the film carrier. A knob is turned engaging the film with a sprocket gear which then advances each frame automatically or manually when the advance switch or remote control button is pressed. The leading end of the film is attached to a take-up spindle, which takes up the film slack and winds it up in its original position.

Filmstrips and audio cassette programs were furnished by ATDA with the projector for test purposes. These filmstrips and audio cassettes were used in all phases of the test in addition to other filmstrips and audio test cassettes designed for specific test measurements, adjustments and quality assurance of picture and sound.

The Army filmstrips furnished for the test contained a square image format that measured .625 x .625 inches. This is slightly smaller than the standard 35mm single frame which measures .668 x .885 inches. Using the Army's

filmstrips requires a longer projection distance to equal the size of the projected image from the standard size filmstrip. The production of filmstrip format is flexible to include the information or artwork and photographs at the expense of the standard size frame.

DESCRIPTION OF MODEL 28A28A PROJECTOR

The Model 28A28A projector's features are summarized in Table 1.

TABLE A1. FEATURES AND CHARACTERISTICS

Dimension HWD (carrying case)	15 x 7½ x 15½ inches
Weight	26 pounds
Projection Lamp	120 volt, 500 watt, ANSI Code BCK, 50 hours, rated life
Power Requirements	120 VAC, 60 Hz
Power Cord	3 conductor, grounding plug
Projection Lens	3 inch f/2.5
Internal Speaker Size	3 x 5 inches
External Speaker Output	16 ohm minimum (accessory external speaker not furnished with unit)
Standard Audio Tape Cassette Player	5 pushbuttons; cassette up, stop, play rewind, and fast forward
Built-In Screen Front Projection	Inside carrying case 10⅛ x 11-3/4 inches
Elevating Knob with Locking Knob	10 degrees maximum
Leveling Devices	Both front legs are adjustable
Amplifier Power	2.5 watts estimated
Remote/Responder Input	Has remote control or responder capability but was not furnished with unit
Earphone Output	Earphones were not furnished with unit
Tape Speed	1-7/8 inches per second $\pm$ 3%

TABLE A2. COST OF MODEL 28A28A PROJECTION SYSTEM MATERIAL

Item	Cost	Quantity
Model 28A28A Projector	$308.00	(GSA 1-11)
Lamp - ANSI Code BCK, 500 watt, 120 volt	$7.47	(GSA case lot of 24)
Reproduction of Filmstrip	$2.20 $1.90	(lot of 10) (lot of 100)
Reproduction of Audio Cassette	$1.66 $1.56	(lot of 10) (lot of 100)

APPENDIX B

TEST DESCRIPTION

TEST PHILOSOPHY AND PROCEDURES

The testing as conducted on the Dukane 28A28A projector can be generally classified as (1) overall machine performance evaluations, (2) accelerated tests of the mechanisms, and (3) accelerated tests of the electronics.

The overall performance evaluations used standard test procedures and are not discussed here. The accelerated tests of the mechanisms and electronics are described in the following paragraphs:

ACCELERATED USAGE TESTS - MECHANICAL

The following test was devised to accumulate primarily mechanical failure data for the filmstrip projector at an accelerated rate of operation. This data was used in computing machine mechanical reliability and maintenance support requirements. The test philosophy was to maximize the number of major machine components to be actuated while minimizing the time to be taken for their actuation. The test consisted of mechanically sequencing a machine through 27,000 typical cycles on a test apparatus simulating a three-year period of machine operation shown in following paragraphs of this appendix. In the test apparatus pneumatic actuators, controlled by a motorized cam switching assembly, initiated play, stop, fast forward and rewind pushbutton functions of the projector's tape deck. Regulated pressure simulated the forces anticipated at each pusbutton to simulate a typical classroom situation, a test cycle of the sequence of events and timing for one software program was selected for machine operation.

One side of a C-60 cassette was recorded with 50 Hz advance pulses of 0.45 seconds duration spaced one every four seconds and at -10 dB level. A typical filmstrip was threaded into the machine and the cassette inserted into the tape deck to enable the test apparatus to exercise the machine in an accelerated manner. This procedure resulted in accelerated action of the pushbutton mechanisms, real-time operation of both the electronics and the film advance mechanism and real-time use of the projection lamps.

ACCELERATED USAGE TESTS - ELECTRONIC

A second test was devised for the purpose of accumulating electronic failure data primarily, but had the secondary function as an accelerated usage test for the filmstrip advance mechanism. This test involved repeatedly stimulating the machine's electronic circuitry with control pulses received from a special test cassette playing through the projector's tape deck. This action resulted in advance of the filmstrip, one full frame for each pulse decoded. Simultaneously, projector lamp failure data was being accumulated.

An endless test cassette was recorded with 50 Hz advance pulses of 0.45 seconds duration spaced one per second and at a -10 dB level. Film was formed into an endless loop within the filmstrip holder enabling the projector to be

operated uninterruptedly by the cassette above. With this software the projector was continuously pulsed and the film advanced at the rate of three thousand per hour, five days per week, an average of nine hours each day. A typical cycle ran for 2.5 minutes followed by a .5 minute rest interval.

TEST DESIGN FACTORS

a. Audio Cassette/Filmstrip Programs

160 Frames - Maximum per Program
80 Frames - Normal Slide Program
120 Frames - Average Program Assumed
5 Seconds - Average Viewing Time Assumed

The calculated average program length (L) was computed as follows:

$$L = \frac{120 \text{ Frames}}{\text{Program}} \cdot \frac{5 \text{ Seconds}}{\text{Frame}} \cdot \frac{1 \text{ Minute}}{60 \text{ Seconds}}$$

$L = 10$ Minutes

The number of programs (P) it is possible to project per hour is:

$$P = \frac{1 \text{ Program}}{10 \text{ Minutes}} \cdot \frac{60 \text{ Minutes}}{\text{Hours}}$$

$P = 6$ Programs

b. The calculated number of machines cycles (NA) occurring in one year was computed as follows:

$NA = H\ D\ W\ P$

H = Hours of Projector Use per Day
D = Days of Projector User per Week
W = Weeks of Projector Use per Year
P = Cycles or Programs Projected per Hour

Assumptions were made that projectors would be used in the field a total of six hours a day, five days a week, for fifty weeks a year and that six ten-minute programs would be shown in an hour.

$$N = \frac{6 \text{ hours}}{\text{day}} \cdot \frac{5 \text{ days}}{\text{week}} \cdot \frac{50 \text{ weeks}}{\text{year}} \cdot \frac{6 \text{ cycles}}{\text{hour}}$$

NA = 9,000 cycles (due to a high number of cycles and frames/hour this represents a maximum usage situation)

The equivalent number of years (Y) of machine testing was then computed:

$$Y = \frac{NT}{NA}$$

NT = Total Machine Cycles

$$Y = \frac{27,000}{9,000}$$

Y = 3 Years

c. Test Cycles Events

Play	0 - 14 Seconds
Stop	14
Rewind	16-28 Seconds
Stop	28
Fast Forward	30-44 Seconds
Stop	44
Rewind	46-58 Seconds
Stop	58 Seconds
Cycle Repeat	60-etc.

d. Results of Tests

(1) Dukane #1

(a) Mechanical (CTL)

27,000 cycles - pushbutton mechanisms
216,000 cycles - film advance mechanism
450 hours - electronic circuitry operation
450 hours - tape deck operation
450 hours - cassette operation
450 hours - filmstrip operation
450 hours - lamps operation

The only significant failures during this portion of the test were the lamps.

(b) Electronic (NAVTRAEQUIPCEN)

185 hours - electronic circuitry operation
185 hours - tape deck operation
185 hours - lamps operation
555,000 cycles - film advance mechanism

Other than lamp failures and torque adjustment, the K1 relay failed at 20 hours.

(c) Combined (CTL and NAVTRAEQUIPCEN)

27,000 cycles - pushbutton mechanisms
771,000 cycles - film advance mechanism
635 hours - electronic circuitry operation
635 hours - tape deck operation
450 hours - cassette operation
450 hours - filmstrip operation
635 hours - lamps operation

(d) Failure Information on Dukane #1

(1) K1 relay failed at 20 hours.
(2) Projection lamps failed as shown in Table B1.
(3) The cassette tape drive belts were worn and considered unuseable (failed at 635 hours)
(4) Other wear factors which did not result in actual test failure in the operational time frame have been provided for in the spare parts replacement list

(2) Dukane #2

(a) Mechanical and Electronic (NAVTRAEQUIPCEN)

675,000 cycles - film advance mechanisms
225 hours - electronic circuitry operation
225 hours - tape deck operation

(b) Failure Information on Dukane #2

(1) K1 relay failed at 170 hours
(2) Projection lamps failed as shown in Table B1

TABLE B1. DUKANE LAMP FAILURES

Unit 1		Unit 2	
Date	Failure Hours	Date	Failures Hours
10/16	40	12/12	52.10
10/30	49	12/24	67.10
11/11	82.42	1/8	64.20
11/13	45.00	1/22	49.00
11/17	55.00		
11/19	52.25		
11/21	47.67		
11/25	53.43		
12/3	64.87		
12/8	56.75		
12/19	49.20		
1/5	59.80		
1/13	57.70		
1/20	19.50[a]		

Average accumulated lmap life: 55 $\pm$ 10 hours

[a](Lamp was broken during maintenance operation)

APPENDIX C

RELIABILITY AND MAINTAINABILITY PREDICTIONS

AMPLIFIER COMPLETE

Part	Name	No.	Fr x 10^{-6}	Total Fr
C1 - C10	Capacitor	19	.27	5.1
CR1, 2, 3, 4	Diode	4	.30	1.2
J1, 2	Connector (6 pin)	2	1.2	2.4
Q1 - Q9	Transistor	9	.9	8.1
R1 - R20	Resistor	32	.25	8.0
R22 - R33				
R21	Potentiometer	1	3.0	3.0
	Connections	136	.5	68.
				95.8

$$MTBF = \frac{1}{96/1,000,000} = 10,400 \text{ hours}$$

HOLD MODULE

Part	Name	No.	Fr x 10^{-6}	Total Fr
C1	Capacitor	1	.27	.27
CR1, CR2	Diode	2	.30	.6
J1	Connector (6 pin)	1	1.2	1.2
Q1, 2, 3	Transistor	3	.9	2.7
R1, 2, 3, 5, 6, 7, 8	Resistor	7	.25	1.75
R4	Pot	1	3.0	3.0
	Connections	30	.4	14.0
				24.52

$$MTBF = \frac{1}{24.5/1,000,000} = 40,800 \text{ hours}$$

OTHER ELECTRICAL PARTS

C1 - C5, C16	Capacitor	6	.27	1.62
CR1 - CR 5	Rectifier	5	.6	3.0
CR6	Zener Diode	1	.15	.15
J1 - J5	Receptacle	5	.30	1.5
K1 - K3	Relay	3	.25	.75
LS	Speaker	1	125.	125.
M1	Motor	1	.3	.3
N1	Pilot Lamp	1	8.0	8.0
P1 - P4	Plugs	4	.3	1.2
Q1	Transistor	1	.9	.9
R1 - R5	Resistor	5	.25	1.25
S1 - S3	Switch	3	200.	600.
SL1	Solenoid	1	.05	.05
TD	Tape Deck	1	2000.	2000.
T1	Transformer	1	1.04	1.04
				2744.76

$$MTBF = \frac{1}{2745/1,000,000} = 364 \text{ hours}$$

TOTAL ELECTRICAL FAILURE RATE

Module	$Fr \times 10^{-6}$
Hold Module	24.52
Amplifier Complete	95.8
Other Electrical Parts	2744.76
	2865.08

$$MTBF = \frac{1}{2865/1,000,000} = 350 \text{ hours overall MTBF}$$

APPENDIX D

RECOMMENDED LEVEL FOR SPARES

MAJOR ASSEMBLY, LOCATED IN FIGURE 1

NOTE

Figures, items, and part numbers referenced in Appendix D correspond to those found in service and parts manual for Dukane 28A28A. Copies of these manuals may be obtained from the Dukane Corporation, Audio Visual Division, St. Charles, Illinois 60174.

Item No.	Item	Part No.	Quantity/Year for 100 Machines
1-1	Tape Deck	594-62	6
1-18	Switch, Slide	680-527	3
1-19	Relay[1]	596-192	33
1-23	Amplifier, Complete	1A975	6
1-28	Foot	290-48	2
1-32	Speaker	645-59	2
1-47	Cap	181-53	2
1-57	Switch, Fan-Lamp	680-529	3
1-58	Lamp	456-96	3
1-59	Potentiometer	601-284	6
1-81	Film Carrier (new)[2]	178-15	3
ADVANCE MECHANISM, LOCATED IN FIGURE 2			
2-1	Sprocket Shaft Assembly	115-4251	2
2-21	Solenoid	659-1	3
2-33	Belt	153-37	18
2-35	Dog Activating Spring	650-66	2
2-45	Take-Up Belt	152-13	18
2-51	Belt	152-31	18
2-66	Fan Motor with Pulley	494-146	4
2-119	Disc, Cone Clutch	233-29	2

[1]Relay has a high failure rate, recommend purchase of proper size or rating.
[2]Film carriers (new), 178-15 are to be purchased in the quantities listed. After replacements have been made, it is suggested that the film carrier be exchanged with factory rebuilt film carriers rather than attempt repairs in the field. The repairs in the field should be limited to the replacement of rear aperture glass only. A substantial savings in money may be realized by this exchange program.

PROJECTION ASSEMBLY, LOCATED IN FIGURE 3

Item No.	Item	Part No.	Quantity/Year for 100 Machines
3-1	Lamp[3]	ANSI BCK	2700
3-10	Lens, Front Condensor	463-101	2
3-16	Lens, Rear Condensor	463-54	2
3-25	Heat Filter	463-100	6
3-39	Lens, Projection	463-170	4

FILM CARRIER, LOCATED IN FIGURE 4

4-3	Glass, Rear Aperture	463-19	4

OTHER PARTS, LOCATED IN FIGURES 6, 7

P26	Capacitor[4]	199-1006-472	33
P26	Cord, AC Line	200-324	18
P27	Resistor, Fusible	600-9067	18
P27	Switch	680-604	3
P27	Transformer	710-4111	2
P27	Transistor (2N5295)	720-33	4
P28	Module, Hold	110-1473	6

TAPE DECK 594-62

1-19	Belt	62-019	100
1-27	AC Motor	62-027	3
1-35	Reel Table Assy. Rew.	62-035	100
1-40	Belt	62-040	100
1-41	Reel Table Assy.Play	62-041	100
1-43	Bell	62-043	500 (lot)
1-50	Pinch Roller	62-050	5
1-55	Record/Play Head	62-055	6
1-60	Brake	62-060	12
1-63	Brake	62-063	12
1-74	Switch	62-074	3

[3] Use GSA schedule, lamp manufacturer.
[4] Replace capacitor when relay, item 1-19, is replaced.

APPENDIX E

MAINTENANCE OPERATION AND SCHEDULES

PERIODIC ROUTINE MAINTENANCE

a. The tape head, pinch roller and capstan should be cleaned with isopropyl alcohol on a cotton swab.

b. The heads and capstan should be demagnetized with a degausser.

YEARLY PREVENTATIVE MAINTENANCE

a. All belts and both reel table assemblies should be replaced at least once a year.

b. Measurements and adjustments should be made using the appropriate test cassettes recommended in the service and parts manual.[1]

c. Replace of other worn or defective parts can be accomplished at the yearly inspection and maintenance cycle.

[1]Service and parts manuals are available for detailed information in the assembly and position of each part in the Dukane Model 28A28A Sound Filmstrip Projector. This includes the tape deck in addition to the projector components.

AUDIO VISUAL

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